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ABSTRACT

During the ninety-eight years since Abraham Lincoln signed the Land Grant College Act, American colleges and universities have prodigiously expanded and extended the activities begun even earlier by alert pioneers. No longer do they limit themselves to the polite learning of interest to the republic of letters. Their services for agriculture and industry sketched here illustrate developments and achievements not only in the "useful arts and sciences" but also in the fundamental knowledge underlying them and modern civilization generally. In sum, American higher education has become integrated with every concern of the nation that requires substantial intelligence and advanced training. (Author)

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THE SERVICES PERFORMED BY AMERICAN COLLEGES AND UNIVERSITIES FOR AGRICULTURE AND INDUSTRY*

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During the decade I spent at Ohio State University, I learned of the incalculable importance in American life of land grant colleges and universities, and early during my studies of the history of higher education I concluded that the 1862 Act of Congress which established them must be judged the most significant piece of higher educational legislation ever passed in this country. It began a new era and has sent ripples even into the smallest coves and creeks of American education. More important, it has helped spur and channel the nation's development. Few if any students of American higher education value and acclaim the work of land-grant institutions more than I.

Conspicuously productive as these colleges and universities have been and are, however, I must confess that the prideful opinions of some of their spokesmen trouble me. The most unrestrained of them give the impression that American higher education stood stock still until the appearance of the land-grant instituions and that they, and they alone, must be credited with setting in motion the concepts and procedures that have integrated our colleges and universities with the workaday interests and needs of the nation. I shall attempt herein to demonstrate the unsoundness of this opinion without, I hope, depreciating the enormous value of the historical and current influences of land-grant colleges and universities.

The topic under discussion, it should be observed, constitutes a sub-division of the larger subject cited in the last paragraph,

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namely, the integration of American colleges and universities into the life of the nation. Until about a century ago higher educational institutions ministered almost exclusively to young men destined for the so-called "learned professions" and the now-almost-forgotten "leisure class," but today they serve people of both sexes and all ages with a myriad of vocational and avocational interests. By means, moreover, of the relatively new functions of advanced instruction, research, and consultation services they directly or indirectly influence the lives of every American and countless people in other countries. A review of why and how this fertile change has occurred can throw useful lights upon the topic of this memorandum, and hence it begins with such an over-all review. Succeeding sections sketch the history and present status of the services performed by American colleges and universities for agriculture and industry.

The Integration of American Colleges and Universities into the Life of the Nation

The nine colonial colleges contributed brilliantly to their times. The population of two and a half million Americans in 1776 included only about two thousand graduates of the nine colleges, but the fifty-six signers of the Declaration of Independence numbered eighteen of them from five of the nine: Harvard eight, Yale four, William and Mary three, Pennsylvania two, Princeton one. Of the committee of five appointed by the Continental Congress to draft the Declaration, three had graduated from colonial colleges: Jefferson from William and Mary, John Adams from Harvard, and Robert R. Livingstone

from Columbia. The other two had not attended college; but Franklin had been the chief founder of the University of Pennsylvania, and Roger Sherman was Treasurer of Yale.

The colonial colleges also had graduated 102 of the 349 members of the Continental Congress -- Princeton twenty-nine, Yale twenty-four, Harvard twenty-three, William and Mary twelve, Pennsylvania eight, Columbia four, and Brown and Rutgers one each. Only Dartmouth contributed no members, but it had been established just a few years before the outbreak of the Revolution in out-of-the-way New Hampshire and did not graduate its first class until 1771.

Of the four members of Washington's first cabinet, the colonial colleges produced three: Jefferson and Randolph of William and Mary and Hamilton of Columbia. The three young men who persuaded New York through the Federalist Papers to ratify the Constitution, thus saving it from defeat nationally, had all been educated in the colonial colleges: Hamilton and Jay at Columbia and Madison at Princeton.

These are but a few of the facts that can be cited to illustrate the importance of the colonial colleges in the early life of the nation. The classical education they gave became outmoded during the nineteenth century, but it equipped the men of the colonial period with both the knowledge and the impetus they needed to be equal to the problems of their fateful times.

During the very year of the signing of the Declaration of Independence, however, a number of other less celebrated events occurred which signalled the beginning of a new age and hence the outmoding not only of the programs of American colleges but also those of

European universities. These events of 1776 included (1) the putting into operation of two of James Watt's steam engines, one in a coal mine and the other in an ironworks, a circumstance that presaged the end of the long Age of Muscle Power and the beginning of the Age of Machine Power; (2) the reading by Antoine Lavoisier of a paper before the French Academy of Sciences anticipating his later promulgation of the law of combustion, a concept that led to the initiation of the New Chemistry and thereby to an enormous leap forward in all the physical sciences; (3) the publication of Adam Smith's The Wealth of Nations, a work which stated the principles that made it possible for entrepreneurs to exploit the steam engine and the flood of other new machines and processes conceived by inventors and scientists; (4) the submission to the Virginia House of Burgesses by Thomas Jefferson and four associates of a series of bills proposing new statutes for that state including those outlawing primogeniture and entails and another establishing religious freedom, bills which Jefferson declared would establish a system of government from which "every fibre would be eradicated of ancient and future aristocracy"[1]; and (5) the presentation by the French encyclopedist Denis Diderot to Catherine the Great of Russia of a plan for the university at St. Petersburg that she contemplated founding, an amazing document which prophetically described the comprehensive American university that began to emerge a century later.

These and other portentous developments of 1776 and surrounding

1. Autobiography, Monticello edition, 1904, 73-74.

years commingled to sound taps on the Age of Muscle Power and reveille for the Age of Machine Power. They also largely nullified the value of the literary education given by the colonial colleges. The new age required educational conceptions and processes that could produce the manpower needed to direct and use the new energies -- social as well as physical -- becoming available with fantastic rapidity to men and nations. It also required massive quantities of new knowledge and large numbers of specialists to develop and to disseminate it among the managers and workers of the fast developing new-type agricultural, commercial, industrial, political, and social institutions spawned by the new forces in the world.

A few discerning men foresaw the advent of the new era and recognized its intellectual and educational implications. These included Benjamin Franklin who anticipated the oncoming age ever before its dawning as witness his 1749 pamphlet Proposals Relating to the Education of Youth in Pensilvania and his efforts some years later to introduce applied science and commercial subjects into the curriculum of the Academy and College of Philadelphia (the University of Pennsylvania since 1791) whose original board of trustees he chaired. Franklin also influenced the first president of King's College (Columbia since 1784) whose initial announcement concerning the studies of the new institution included the following passage:

> . . . it is further the Design of this College, to instruct and perfect the Youth in the Learned Languages, and in the Arts of reasoning exactly, of writing correctly, and speaking eloquently; and in the Arts of numbering and measuring; of Surveying and Navigation, of Geography and History, of Husbandry, Commerce, and Government, and in the Knowledge of all Nature in the Heavens above us, and in the Air, Water, and Earth around us, and the various kinds of Meteors, Stones, Mines, and Minerals, Plants and Animals, and everything useful for the

> Comfort, the Convenience and Elegance of Life, in the Manufactures relating to these Things: And finally, to lead them from the Study of Nature to the Knowledge of themselves, and of the God of Nature . . . .[1]

This statement proposed a curriculum that would cover the whole range of human interest; but, like similar proposals made by other pioneer statesmen and educators during the next century, it did not take hold for at least four reasons.

In the first place, the American colonial colleges and their successors for an extended period served those in or desiring to become members of "the ruling classes." Not a few of their students came from economically underprivileged families who sought a college education to improve their lot in life, that is, to promote what would today be called upward social mobility. Otherwise expressed, they desired to be "gentlemen"; and that meant that upon graduation they would enter the occupations open to gentlemen: the church, law, medicine, and public life. Some became gentlemen farmers, and a few entered the businesses of their non-college fathers; but predominantly they steered clear of occupations related to commerce and industry for the reason that, ever since Plato and Aristotle poured their contempt upon them, all utilitarian careers had been considered beneath the dignity of gentlemen.

Even late in the nineteenth century this attitude continued to thrive in some colleges as witness the statement of James H. Tufts of the Amherst Class of 1884 that the plans of a classmate to become

1. New York Gazette and Weekly Post Boy, June 3, 1754.

a businessman led to critical gossip. The proposal of President Samuel Johnson of King's College that the colleges offer "useful" courses in "husbandry, commerce, and manufactures" could make but slow headway in the face of such deep-seated opposition to the "servile studies."

"Useful" courses came into the curriculum slowly for a second reason, namely, the conviction of college authorities that Greek and Latin literature encompassed the wisdom of the ages and could be neglected only at great peril to the health of society. President Josiah Quincy of Harvard voiced the opinion of the great majority of pre-Civil War educators on this score when he wrote in 1840:

> At the present day, indefinite desires for the improvement of all public literary institutions press from without, while a natural fear of attempts at impracticable innovations is existing within. An age, almost lawless from love of liberty, is calling for restraints to be practised in them which it neglects to teach by example, and shows no disposition to enforce elsewhere; clamorous that institutions of learning should keep pace with its spirit, without inquiring whether this spirit be of a permanent or transitory character . . .
>
> They [the colleges] should defer action until after a thorough understanding of the true relations of the subject, and a fair comparison of the views of practical men within, and of practical men without, the institution; remembering that the safe ways are the trodden paths; that the new, though tempting, are often uncertain; and their termination unknown; that to follow public opinions is easy and popular, but that this opinion is not always sound, and is liable to be corrupt; that the schemes of the present time are apt to be urgent and selfish, but the wisdom of antiquity is ever unobtrusive and disinterested. The measure of intellectual greatness is not the average breadth of every man's span, at the present day, but the broad and muscular palm of those giants of former times, which they have left apparent and chiselled upon works little less admirable than those of nature herself, and imperishable as her mountains.[1]

1. Josiah Quincy, The History of Harvard University, 2:456-457.

The context of this statement brings into focus the third reason that American colleges shunned "useful" subjects, to wit, they were "literary seminaries" devoted to the concerns of "the republic of letters" and not to those of society as a whole.

The medieval universities primarily and some of them "almost exclusively [were] occupied with professional education,"[1] but the Renaissance had converted the two English universities into agencies for civilizing the sons of the landed gentry and of the rising mercantile class "enriched by the woolens trade and overseas commerce."[2] These new-type students had no interest in the dialectical hair-splitting of the medieval liberal arts and little in professional training. They sought instead what went by the name of "polite learning," that is, the social polish that Erasmus and other "humanists" declared could be theirs if they studied the classics of Greece and Rome.

This educational emphasis crossed the Atlantic with the colonists; and although the term "polite learning" did not prosper in the American atmosphere, the colonial colleges and those later established in their tradition gave their chief allegiance to the interests of "the republic of letters" and generally neglected other sectors of the community. As William Graham Sumner pointed out as late as 1883, they habitually looked upon economically useful subjects as

1. Hastings Rashdall, The Universities of Europe in the Middle Ages, 1936 revision, 3:461.

2. Samuel Eliot Morison, The Founding of Harvard College, 1935, 54.

vulgar and hence inadmissible to their curriculums.

The three reasons just cited for the slow development of broad programs of study in American colleges and universities do not tell the whole story, but they suffice to introduce the fourth and perhaps most potent of all the reasons for educational retardation, namely, the lack of awareness of educators and of all but a handful of the intelligentsia that a new era had begun, an era to be dominated by massive new forces and by such novel or neglected concepts as Progress, Evolution, Nationalism, and Democracy. President Quincy of Harvard could not have composed the statement quoted two pages back had he comprehended the significance of such events as the patenting that year of Samuel F. B. Morse's device for sending messages over wires; nor could the Yale Faculty of 1828 have written its famous denunciation of the new demands being made of the colleges had it understood the implications of the laying of the rails of the first American "steam road" in Baltimore that Fourth of July; nor could the utilitarian program of the University of London, founded that same year, have been greeted by Oxford, Cambridge, and their adherents as a "new-fangled scheme of pantology"[1] had they discerned the import of the Corn Law presented to Parliament in mid-July.

As observed earlier, however, perceptible people like Benjamin Franklin sensed the end of the long Agrarian Epoch and the onrushing of the Technological Era. These men set about the arduous and unfavored business of integrating the schools and higher educational

1. Mark Pattison, Oxford Studies, 1855, 262.

institutions of the country with the broadening activities, interests, and needs of Americans. In the following sections I describe their accomplishments in the two fields named in the title.

Agriculture

The practicentric Romans had an abiding interest in agriculture, and adaptations of the books about it written near the beginning of the Christian era by Columella, Pliny the Elder, and Varro continued to be authoritative into the eighteenth century. Recent investigations have shown that inventions such as the horse collar and the horseshoe (products of the tenth century) led to improvements in agriculture, but the learned world did not contribute to these developments. Primarily preoccupied with theocentric and logocentric problems, it left such "servile" matters to unlettered and "vulgar" men. Not until the nineteenth century would the academic world be forced by circumstances and the proddings of seminal thinkers to attend to the oldest and most essential of human arts and industries.

Industrialization, urban growth, and population increase constituted the chief circumstances. These created agricultural problems that triggered the imagination of men endowed with mechanical skill, and late in the eighteenth century Eli Whitney invented the cotton gin and Newbold and Wood the first crude iron plows. In rapid succession thereafter came the grain cradle, the hay rake, the reaper, the threshing machine, and scores of other new farming implements. Meanwhile President Washington in his messages to Congress urged the insistent necessity of improved agricultural knowledge.

Jefferson, a working farmer when not in public service, similarly encouraged agriculture which he had discussed in detail in his Notes on the State of Virginia and in his letters concerning the subjects to be studied at his brain-child, the University of Virginia.

Agriculture inevitably preoccupied the interests of Americans since in 1800 just over ninety-six percent of the nation's population lived on farms or in villages primarily dependent upon them. New York, which had just passed Philadelphia to become the largest city, had 60,515 inhabitants; but its economy rested largely upon agriculture and associated industries and commercial enterprises. The transportation of farm products and of merchandise for farmers over the Erie Canal, opened in 1825, gave it the name of the Empire State. As I shall describe later, Professor John Kemp of Columbia College proposed the canal to his student DeWitt Clinton, its energetic promoter. In 1791 Kemp also helped organize the New York Society for the Promotion of Agriculture, Arts, and Manufactures which had counterparts in other states.

These societies became earnest advocates of the utilitarian education that the colleges, traditionally limited to serving the republic of letters, disdained and ignored. Their activities led during the third and fourth decades of the century to the establishment of numerous manual labor schools and colleges in which students both studied and did farm labor, but the plan proved impracticable. Thus private and public institutions exclusively or primarily devoted to agricultural education came upon the scene in at least eight states beginning with Delaware and Vermont in 1834. None prospered, however, until after the passage of the Land Grant College Act in 1862.

In the interim Yale became the nation's pioneering center of agricultural education, research, and service.

In 1846-47 two young private scientific entrepreneurs induced Yale to let them use its name in their successful effort to establish scientific agriculture as a recognized academic pursuit. They were John Pitkin Norton and Benjamin Silliman, Jr., the latter the son of Yale's distinguished Professor of Chemistry, Minerology, Pharmacy, and Geology who began his teaching career in 1802. In the summer of 1846 the elder Silliman presented to the Yale Corporation a document, written by his son, entitled "Proposals for Establishing a Chair of Agricultural Chemistry and Vegetable and Animal Physiology." The Corporation approved the proposal in August and a year later appointed Norton, aged twenty-four, to the professorship named therein and young Silliman, aged thirty, "professor of chemistry and the kindred sciences as applied to the arts."

Yale, however, gave no money for the support of the venture; and, in the words of one of its historians, "it is more than doubtful if it would have given it" since the impression "seemed generally to prevail that chemistry, like virtue, must be its own reward."[1] Norton and Silliman therefore used their own funds to rent a building for their laboratory and to buy equipment. Their income consisted of the fees paid by their students -- eight during the first year and eleven during the second. They called their project the Yale School of Chemistry which, to give the two young adventurers faculty status,

1. W. L. Kingsley, Yale College: A Sketch of Its History, 1879, 2:106.

the Corporation made a division of the created-for-that-purpose Department of Philosophy and the Arts. Their little school constituted "the arts," a term which in those days referred more frequently to the utilitarian than to the liberal arts.

The interesting but complex story cannot here by told of how Norton's death in 1852 led to Yale's unenthusiastic acceptance of responsibility for the School of Chemistry, how it evolved into the Yale Scientific School and then into Sheffield Scientific School, and how the Department of Philosophy and the Arts became the Yale Graduate School and in 1861 conferred the first American Ph.D. degree. No less interesting and more relevant in this context are the facts about the work in agriculture done by Norton and his successors.

As a boy Norton, son of a wealthy Connecticut farmer, had decided to learn about the scientific farming that Sir Humphry Davy's 1813 book Elements of Agricultural Chemistry had initiated in England and to a degree in the United States. Having no interest in the classical languages, he did not enter Yale College but instead studied as a private student of the elder Silliman who arranged for him to go abroad for advanced instruction at the University of Edinburgh and the University of Utrecht. There he learned of the momentous studies and methods of Professor Justus von Liebig of the University of Giessen who in 1840 had published his history-making Organic Chemistry Applied to Agriculture.

Even before returning home Norton began his own studies in agricultural chemistry and won a prize of fifty sovereigns from the Highland Agricultural Society for a paper on oats. This he followed with other articles published in the American Journal of Arts and

Sciences which the senior Silliman owned and edited. They related to the diseases of potatoes and to the protein content of almonds, oats, and peas. His death from overwork soon after his thirtieth birthday ended the career of the first American professor of agriculture and of the man who, more than any other, initiated scientific efforts to improve the procedures and products of American farmers, stockbreeders, and the rapidly expanding agricultural industries.

The extraordinary development of state-supported agricultural colleges during the last quarter of the nineteenth century led the Sheffield Scientific School to discontinue work in the subject in 1903,[1] but Norton's successors carried on what he started. This included not only resident instruction and research but also continous services for national agricultural enterprises. Thus John A. Porter, a student of Liebig's who assumed Norton's professorship in 1852, promoted the land-grant college movement by four years later publishing his "Plan of an Agricultural School" and by bringing together in New Haven several hundred agricultural leaders at an 1860 conference on the latest scientific findings in their field. He also solicited their support of the legislation pending in Congress relating both to the Morrill Act and to the proposed United States Department of Agriculture. President Lincoln signed the act establishing the latter

1. Harvard, which began agricultural instruction in 1869, abandoned it in 1907 after granting only a few dozen S. Agri. B. degrees. Six years earlier it had also closed its Veterinary School after a life of nineteen years. In these fields Harvard could not compete successfully with the Massachusetts Agricultural College at Amherst and with Cornell.

seven weeks before the former, and beyond doubt Porter's conference helped ensure both signatures.

Like Norton, Porter died young; but before his death in 1866 he played the major role in bringing the first of the Sheffield benefactions to Yale (they totalled over a million dollars)[1] and also to get the Connecticut Legislature to assign the federal grant of 1862 to what had meanwhile become the Sheffield Scientific School.[2] This additional financing made possible the appointment of two professors of agriculture -- Samuel W. Johnson and William H. Brewer both of whom had also studied in Germany with the pivotal Liebig.

Johnson and Brewer not only established the nation's first agricultural experiment station a dozen years before the Hatch Act of 1887 created one in each land-grant institution, but they also undertook extensive investigations and extramural services. Johnson, for example, did the research which led to the Connecticut law of 1869 requiring that the composition of fertilizers be labelled on their containers, a pioneering effort later followed over the country and making Johnson the founder of agricultural regulatory procedures. Brewer in turn became perhaps the leading American authority on cereals, and, among many other studies, carried out investigations for the federal government on the manufacture of glucose sugar from starch, the sorghum sugar industry, and the preservation of the forest

1. He married Sheffield's daughter.

2. Sheffield continued to be the land-grant college of the state until 1893 when the legislature transferred the federal funds to the antecedent of the present University of Connecticut.

resources of the country.

Before the maturation of the magnificent agricultural schools of publicly-supported universities like Cornell and California and those in the Middle West, Yale agriculturists for a brief period had pre-eminent status. By no means, however, did they monopolize the field. Other chemists as well as geologists and botanists did no less significant work. Those on the faculties of private institutions included James C. Booth of the University of Pennsylvania who worked on sugar and molasses, Eben H. Horsford of the Lawrence Scientific School at Harvard who in 1861 wrote the definitive book on breadmaking and who also developed processes for the manufacture of baking powder and condensed milk, and George H. Cook of Rutgers who did studies of the salt deposits in central New York for the Onandaga Salt Company. Professors on the faculties of state universities founded before the passage of the land-grant legislation of 1862 included the controversial Thomas Cooper of South Carolina whose extensive studies included some on tests for arsenic, John W. Mallett of Alabama and Virginia who in 1862 published a major work on the cultivation of cotton, and E. W. Hilgard who in Mississippi before the Civil War became the country's foremost authority on soils.

Even though I have barely scraped the top of the subject, perhaps I have written enough to justify the generalization that for well over a century American agriculture has been the beneficiary of the instruction, research, and services initiated by and conducted in American colleges and universities. Working against the classics-oriented convictions of the majority of their colleagues, professors of agriculture and related subjects succeeded in integrating American higher

education with the life of the nation at the strategic point of physical survival and nutritional health. Further, they helped prepare the way for the flowering of the comprehensive university visualized by Diderot in 1776. In sum, they established patterns whose values to the United States and, indeed, to the world cannot possibly be calculated.

Industry

In an 1894 anthology describing "the existing conditions of the United States," its editor and chief author, Professor Nathaniel S. Shaler of Harvard, wrote that "it is in the profession of the engineer . . . that our people have made the greatest advances."[1] The first engineering feat to attract the attention of the world and to instill pride in Americans seems to have been the Erie Canal begun on July 4, 1817 and opened late in October, 1825. At least two college professors played a significant part in the achievement -- John Kemp of Columbia College and Professor Amos Eaton of a small medical school in Vermont.

I have not been able to discover whether Professor Kemp originated the idea of the canal, but it seems clear that he first suggested it to the man who later became its chief protagonist. Kemp, a graduate of the University of Aberdeen and professor of mathematics, natural philosophy, and geography at Columbia beginning in 1786, knew about the canal constructed in 1759 from Manchester to Worsley in

1. The United States of America, 1894, 2:630-31.

Lancashire and undoubtedly about other European canals. His knowledge of geology and geography made him see the practicality of a waterway connecting the Great Lakes and the Hudson, and his enthusiasm for the idea inspired his student DeWitt Clinton. Later Kemp toured various routes with Clinton and other members of the Canal Commission and helped select the one eventually followed. Amos Eaton in turn made geological and agricultural studies preparatory to the digging.

A year before the inauguration of the Erie Canal, Eaton became the senior professor at the school founded in Troy, New York, that developed into the first American center, other than West Point which had been established in 1802, for the training of engineers. Stephen Van Rensselaar, the large-minded patroon who organized and financed the school (in 1861 it took its present name of the Rensselaer Polytechnic Institute) projected it primarily "to qualify teachers . . . in the application of experimental chemistry, philosophy, and natural history to agriculture, domestic economy, the arts and manufactures."[1] In this purpose Rensselaer succeeded spectacularly, "the majority of naturalists and engineers who were teachers or practitioners in the United States" in 1850 being its alumni.[2] Many of them had previously graduated from Harvard, Yale, Princeton, and other "literary seminaries" in the eastern states making Rensselaer in fact if not in name

1. R. P. I. Bulletin, March, 1940, 7.

2. Ray Palmer Baker, A Chapter in American Education, 1924, 7.

the nation's first graduate school.

Before the war between the states, West Point also supplied the nation with a large number of "civil" engineers, the most important being George Washington Whistler of the Class of 1819 and father of the famous painter. The Army assigned Whistler to railroad engineering, and after his resignation in 1833 his work building a railroad through the Berkshires led representatives of the Czar to select him to build the first Russian railroad and construct fortifications and bridges. Everyone knows of Whistler's portrait of his mother, but the general ignorance of his father even among historians testifies to the low esteem that he and other utilitarian achievers still have in the eyes of many members of "the republic of letters."[1]

Some educators, however, early saw the need of education for what the Land Grant College Act called "the industrial classes"; and they joined forces with leading citizens like Van Rensselaer to promote and dignify it. Brown University and Union College together furnished two of the most important of these educators -- Eliphalet Nott, a graduate of Brown and president of Union for sixty-two years beginning in 1804, and Francis Wayland, a graduate of Union and president of Brown from 1827 to 1855. Nott also served as president of R.P.I. during the period in which it made engineering its chief concern, and

1. The nineteenth century French entomologist Henri Fabre wrote that historians "know the names of the king's bastards" but scorn "to speak of the plowed fields by which we thrive." In recent decades social historians have extended the range of academic history, but the neglect of the "useful arts and sciences" continues among not a few professors of history. The American Mind by Henry Steele Commager, for example, includes nothing about the thinking and work of those concerned with agricultural, industry, and other technical pursuits.

at Union he organized the first scientific and engineering courses in a traditional American college. Wayland wrote the most perceptive and influential book about American higher education to be published before the Civil War and therein included passages like the following:

> . . . a very large class of our people have been deprived of participation in the benefits of higher education. It has been almost impossible in this country, for the merchant, the mechanic, the manufacturer, to educate his son, beyond the course of a common academy unless he gave him the education preparatory to a profession . . . Now the class of society that is thus left unprovided for, constitutes the bone and sinew, the very choicest portion of this or of any community . . . It is of the very highest importance, on every account, that this portion of a people should possess every facility for the acquisition of knowledge and intellectual discipline.[1]

Five years after the appearance of Wayland's book the Yale School of Chemistry, earlier cited, came upon the scene; and the same year so too did the Lawrence Scientific School of Harvard. Both attended to "the application of science to the useful arts." Soon thereafter other "literary seminaries" organized comparable sub-structures; and during the same period a number of unitary schools of science and engineering also emerged. The most famous of the latter, Massachusetts Institute of Technology, got its charter the year before the passage of the Morrill Act. Its chief promoter, William Barton Rogers, had quit the faculty of the University of Virginia some years earlier to campaign for its establishment.

Rogers, one of four eminent sons of Patrick K. Rogers who taught natural philosophy and chemistry at William and Mary, had long

1. Francis Wayland, Thoughts on the Present Collegiate System in the United States, 1842, 154.

been concerned with engineering and manufacturing problems; and in 1848 he had published his Strength of Materials and in 1852 his Elements of Mechanical Philosophy, both pioneering works. His older brother James Blythe Rogers had similar interests and, beginning in 1827, served as chemist for a manufacturing firm in Baltimore while teaching the subject in a local medical school. His numerous articles reported experiments concerned with arsenic poisoning, the voltaic battery, and the solubility of copper in hydrochloric acid.

The greatest strides in technology came not from the work of the handful of professors who bucked the prevailing literary tradition of the colleges but from little-schooled "practical" men who did the bulk of the canal and railroad building of the period, who constructed turnpikes and bridges, and who invented the machines and devices upon which the later technological success of the country chiefly rested. Two professors, however, are numbered among the fourteen men whose twelve inventions the United States Patent Office listed in 1936 as the greatest made by Americans during its first century -- Samuel F. B. Morse who held the title of professor of literature and fine arts at the institution which grew into New York University but who never performed its functions, and Alexander Graham Bell, professor of vocal physiology at Boston University. Three of the others -- Eli Whitney, George Westinghouse, and Charles M. Hall who invented the process for making aluminum -- had attended college[1] where unsung professors cultivated their interest in science and its

1. Yale, Union, and Oberlin respectively.

applications. The remaining nine[1] were what Lewis Mumford has called "tinkers and mechanics."

Before the development of the mighty engineering schools to whose quickening the Morrill Act so considerably contributed, professors on the faculties of established collleges performed fundamental technological services. As far as I can discover, no one has investigated this topic extensively, but in all probability such a study would identify many more than the seven professors whose activities I summarize below:

> James Curtis Booth, Professor of Chemistry Applied to the Arts at the University of Pennsylvania beginning in 1851, who did basic studies of minerals, especially of iron, as well as of the refining of sugar and the manufacture of molasses.
>
> George J. Brush, Professor of Metallurgy beginning in 1855 and later Director of the Sheffield Scientific School, whose work on minerals won him recognition in England, Scotland, and Germany as well as in the United States.
>
> Walcott Gibbs, Professor at C.C.N.Y. before going in 1863 to the Rumford Professorship of the Application of Science to the Useful Arts at the Lawrence Scientific School. Another one of Liebig's students, he did classical investigations on the complex compounds of cobalt and later of a series of other metals.

1. Thomas A. Edison, John Fitch and Robert Fulton, Charles Goodyear, Elias Howe, Cyrus McCormick, Otto Mergenthaler, and the Wright Brothers.

William M. Gillespie, Professor of Civil Engineering at Union, whose 1847 A Manual of the Principles and Practices of Road-Making and 1855 Treatise on Land-Surveying continued to be standard works long after his death in 1868.

James Renwick, Professor of Natural Philosophy and Experimental Chemistry at Columbia, who wrote A Treatise on the Steam Engine in 1830 and Applications of the Science of Mechanics to Practical Progress in 1840 and who did extensive consultation work for the United States government and for railroad builders.

Benjamin Silliman, Jr. of Yale who helped Charles Goodyear to develop the method of vulcanizing rubber and whose researches led to the establishment of the petroleum industry.

J. Lawrence Smith, Professor of Chemistry at the University of Virginia, who before the Civil War served as adviser to the Turkish government on cotton culture and who while in Turkey discovered coal and emery deposits which proved of considerable economic value to that country.

My present graduate students include a Yale bachelor of mechanical engineering, and I hope to be able to interest him in investigating more thoroughly the services performed for American industry by college and university engineers and other professors. Meanwhile these notes about the accomplishments of institutions in operation before the passage of the Morrill Act evidence the interest of at least some of their faculty members -- and of the administrators who appointed and supported them -- in the problems and needs of their pregnant times.

Summary and Conclusion

During the ninety-eight years since Abraham Lincoln signed the Land Grant College Act, American colleges and universities have prodigiously expanded and extended the activities begun even earlier by alert pioneers. No longer do they limit themselves to the polite learning of interest to the republic of letters. Their services for agriculture and industry sketched here illustrate developments and achievements not only in the "useful arts and sciences" but also in the fundamental knowledge underlying them and modern civilization generally. In sum, American higher education has become integrated with every concern of the nation that requires substantial intelligence and advanced training.

Especially since the end of the second World War, moreover, American academic experts have increasingly made their know-how available to less favored peoples. Long ago prescient students of American life foresaw this development and its implications. Witness, first, the concluding paragraph of an article entitled "The New Education" by Charles W. Eliot, the young chemist who a few weeks after its publication early in 1869 became president of Harvard, and second, a statement written by Alexis de Tocqueville in 1835. Wrote Eliot:

> Americans must not sit down contented with their position among the industrial nations. We have inherited civil liberty, social mobility, and immense native resources. The advantages we thus hold over the European nations are inestimable. The question is, not how much our freedom can do for us unaided, but how much we can help freedom by judicious education. We appreciate better than we did ten years ago that true progress in this country means progress for the world. In organizing the new education, we do not labor for ourselves alone.[1]

1. The Atlantic Monthly, March, 1869, p. 367.

De Tocqueville concluded the first volume of his Democracy in America as follows:

> There are, at the present time, two great nations in the world which seem to tend towards the same end, although they started from different points: I allude to the Russians and the Americans. Both of them have grown up unnoticed; and whilst the attention of mankind was directed elsewhere, they have suddenly assumed a most prominent place amongst the nations; and the world learned their existence and their greatness at almost the same time.
>
> All other nations seem to have nearly reached their natural limits, and only to be charged with the maintenance of their power; but these are still in the act of growth . . . The Anglo-American relies upon personal interest to accomplish his ends, and gives free scope to the unguided exertions and common-sense of the citizens; the Russian centers all the authority of society in a single arm: the principal instrument of the former is freedom; of the latter servitude. Their starting-points are different, and their courses are not the same; yet each of them seems to be marked out by the will of Heaven to sway the destinies of half the globe.[1]

It does not require the perspicacity of a de Tocqueville to comprehend the desirability if not necessity during this post-sputnik era of recalling Eliot's epigrammmatic declaration that "We do not labor for ourselves alone." The New Educators never have, and happily their adherents multiply throughout American collleges and universities and in their outposts over the world.

1. The Colonial Press 1899 edition, 1:441-42.